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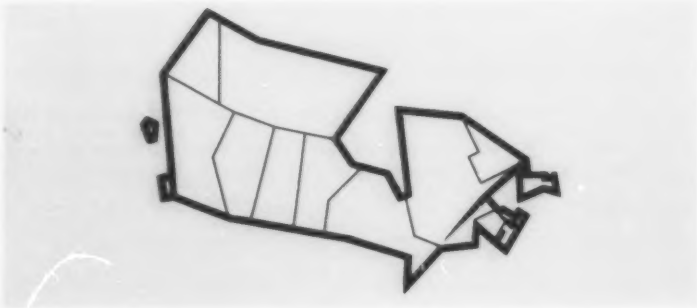

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Soil moisture available at seeding on the Canadian prairies

A. BOOTSMA, J. DUMANSKI, and R. DE JONG
Land Resource Division
Centre for Land and Biological Resources Research
Ottawa, Ontario

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Introduction

The availability of soil moisture at seeding time is an important factor in the production of spring grains in the prairie region. In many years, rainfall during the growing period is insufficient to meet crop requirements so that moisture stored in the soil becomes crucial for achieving economical yields. In drier regions of the prairies, summerfallowing is a proven technique used to increase plant available soil moisture in the subsequent year, thus reducing the risk of crop failure. However, the practice of summerfallowing is considered to be detrimental to soils by increasing erosion, nutrient loss and salinization.

Flexible cropping systems wherein moisture reserves at seeding are used to determine if land should be recropped or fallowed are preferred options to traditional cropping systems in the drier areas of the prairies. Bole and Freeze (1986) termed the "break-even" level of moisture reserves as "that level which would, with average precipitation, provide equal return from recropping or summerfallowing the land to crop the next growing season". They determined that the break-even level for barley in the Dark Brown and Black soil zones of Alberta varied from 72 to 90 mm, depending on barley prices. Break-even levels may differ with soil-climatic zone and for different crops. At moisture levels above the break-even level, it becomes economically feasible to stubble crop.

It has been estimated that under optimum conditions (i.e. adequate soil fertility, reasonable growing season rainfall distribution and adequate weed control) that each mm of plant-available moisture stored in the soil in spring can add 8.5 to 10 kg/ha to the yield of spring wheat (De Jong, 1990). The amount of moisture stored will depend on climate, soils and management factors (e.g. stubble or fallow cropped, snow trapping with use of stubble). This bulletin presents estimates of the variation in available moisture in spring over time and space in the prairie region for soils with different water-holding capacities. The values presented will be helpful as indicators of how frequently stubble cropping is feasible and the yield response expected by fallowing.

Soil Moisture Budgeting

Seasonal distribution of moisture in the soil profile is a complex interaction of many variables. These include patterns of weather, types of soils, kinds of crops grown and agricultural management practises. A water budget model called the Versatile Soil Moisture Budget (Baier, et al., 1979) has been developed to estimate soil moisture by solving a simple water balance equation on a daily time scale. Water is added to the soil profile by precipitation and it is removed by evapotranspiration, runoff and deep percolation. These procedures were used to estimate available moisture for each day of a 30-year period (1956-1985) for spring wheat.

The analysis was carried out for the Agroecological Resource Areas (ARAs) of the prairie region (Pettapiece, 1989; Eilers and Mills, 1990; G. Padbury, personal communication). These are areas which are relatively uniform with regard to soils, landscapes, climate and crop production potential. A climatic data base (daily maximum and minimum air temperature and precipitation) for the 1956-1985 period was developed for each ARA by weighting the data from climate stations in or near the ARA. Water budgeting procedures were then applied to sandy, loam, clay loam and clay soils (as represented by available water-holding capacities (AWCs) of 100, 150, 200 and 250 mm respectively) in each ARA. Seeding dates used for each year of the 30-year period were based on recorded Crop Reporting District data (Statistics Canada).

Soil moisture levels fluctuate widely from year to year and therefore results are expressed in terms of probability or risk. The 50% probability, which is equivalent to the long term average (assuming a normal distribution), is the moisture content not exceeded in half (50%) of the years. The 10% value is the moisture content not exceeded 1 year in 10, or conversely, it is exceeded 9 years in 10.

Soil moisture estimates presented here are based on 30 years of daily climatological data (1956-1985). Although it is possible that some climatic changes could occur in the future because of the 'greenhouse' effect or other factors, any change is expected to be very gradual and therefore the past 30

years should provide a good estimate of soil moisture conditions expected in the next decade or more.

Soil Moisture at Seeding

Figure 1 shows the average (50% probability) estimated soil moisture available at seeding for continuous wheat for the predominant soil AWC of each ARA. An equivalent map for the crop year in a wheat/fallow rotation is shown in Figure 2. These estimates were made assuming the AWC of the most common soil in each ARA (Figure 3).

For continuous wheat (Figure 1), the soils located in the Brown and Dark Brown Chernozemic soil areas of southeastern Alberta and southwestern Saskatachewan have estimated moisture contents at seeding typically in the range from 41 to 100 mm at 50% probability, with a few ARA's dropping to below 40 mm. It is in these areas that summerfallowing is most frequently practised. Soils in the Black Chernozemic soil zones typically contain 71 to 130 mm at 50% probability, with a few ARAs even higher. A map of the major soil groups in the prairie provinces is shown in Figure 4.

Estimated water contents in the crop year of wheat/fallow rotations (Figure 2) are somewhat higher than continuous wheat in all areas. Soils in the Brown and Dark Brown Chernozemic soil areas have typically 71 to 130 mm, although a few ARAs have a value of 70 mm or lower. Soils in the Black Chernozemic soil zones have moisture contents typically in the range of 101-160 mm, at the 50% probability level with a few ARAs having less than 101 mm or greater than 160 mm.

Conversion Procedures for Sub-dominant Soils and other Probabilities

The maps illustrated in Figures 1 and 2 are based on the AWC for the most common (or dominant) soil in each ARA (see Fig. 3). However, other types of soils may also be present and the following procedures describe how estimates can be made for these sub-dominant soils as well.

Soil moisture values for other soils (AWC's) and other than 50% probability may be readily estimated by using Figure 5 for continuous wheat and Figure 6 for wheat/fallow rotation. These maps, however, must be used in conjunction with

Figure 3 and Table 1.

Figures 5 and 6 show moisture contents not exceeded at 10% probability at seeding for a clay soil (250 mm soil AWC) for continuous wheat and for a wheat/fallow rotation, respectively. Table 1 is a correlation table for other soil AWC's and other probabilities in relation to the 250 mm soil AWC, (10% probability) (correlations are similar for both continuous wheat and wheat-fallow rotation). Using Figures 5 and 6 and Table 1, it is relatively simple to estimate soil water content at spring seeding for any one of sandy, loam, clay loam or clay soils (100, 150, 200, and 250 mm AWC) and for probability levels ranging from 5 to 50%. For example, ARA's with 41 to 70 mm of water at 10% probability for a 250 mm AWC soil will have 22 to 38 mm of available moisture for loam soil (150 mm AWC) at 10% probability (1 yr in 10) and 17-31 mm at 5% probability (1 yr in 20).

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Figure 4. Location of major soil groups in the prairie region.

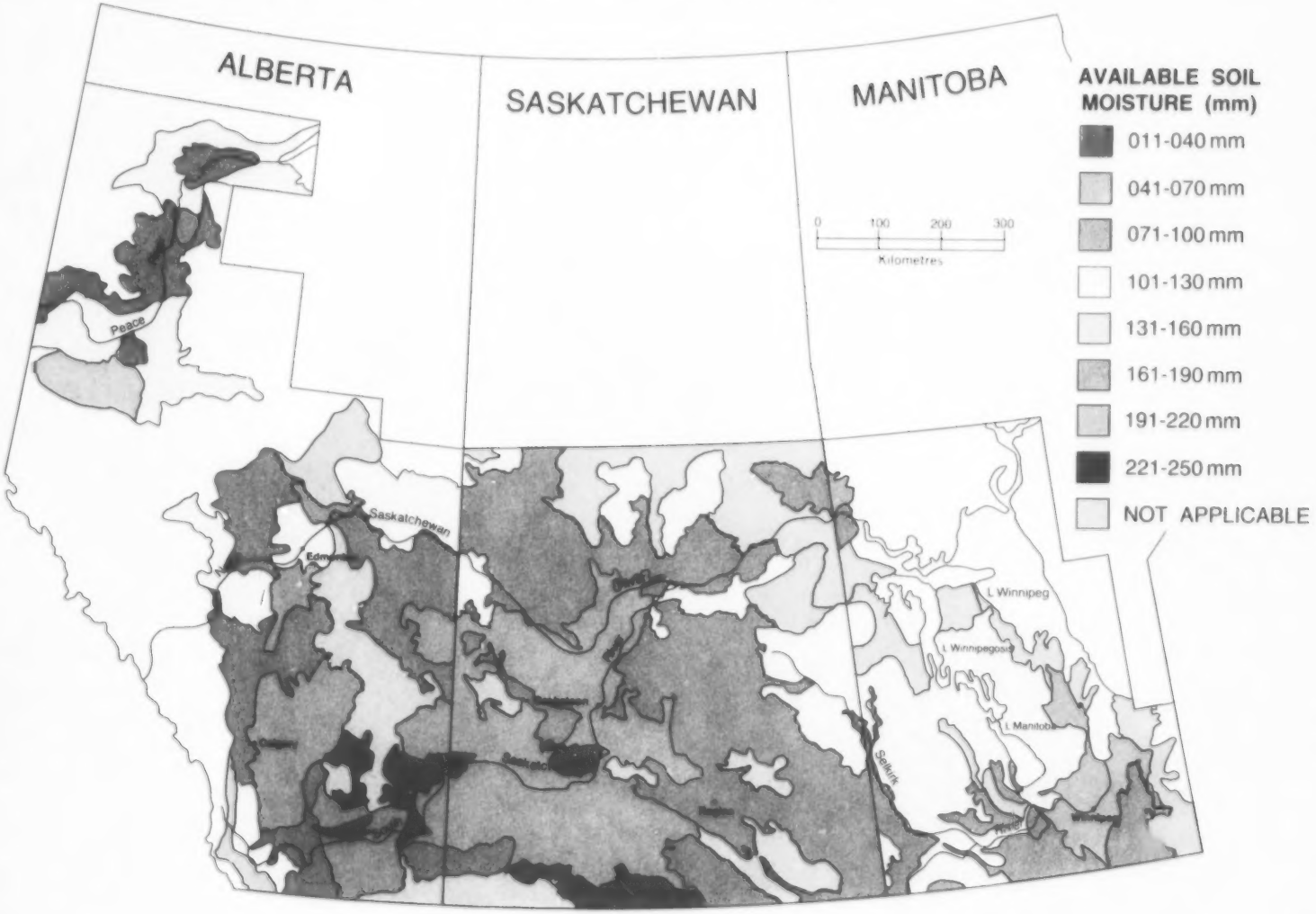
Figure 5. Available soil moisture (mm) at seeding for 250 mm soil AWC, 10% probability, continuous wheat rotation.

Figure 6. Available soil moisture (mm) at seeding for 250 mm soil AWC, 10% probability, wheat/fallow rotation.

Table 1. Estimated available soil moisture (mm water) at seeding not exceeded at probability levels shown for 4 soil AWCs for both continuous wheat and a wheat-fallow rotation (only the upper limit of each class is shown).

Soil Moisture (mm) for 250 mm AWC 10% prob.	Soil moisture (mm) for other soil classes (AWCs) and probability levels														
	Sandy loam 100 mm AWC				Loam 150 mm AWC				Clay loam 200 mm AWC				Clay 250 mm AWC		
	5%	10%	25%	50%	5%	10%	25%	50%	5%	10%	25%	50%	5%	25%	50%
40	15	18	29	50	16	21	28	43	32	38	49	67	33	54	73
70	32	40	55	69	31	38	54	78	57	65	84	109	61	88	113
100	47	55	68	77	48	57	79	102	82	93	115	142	89	122	153
130	59	66	74	80	66	77	99	118	106	119	142	164	118	155	188
160	67	71	75	80	84	96	114	126	129	142	162	177	146	185	214
190	70	72	76	82	102	112	122	128	150	160	173	179	175	209	227
220	70	72	80	85	120	122	122	129	170	173	174	180	203	225	228

Figure 1. Available soil moisture (mm) at seeding for continuous wheat at 50% probability.



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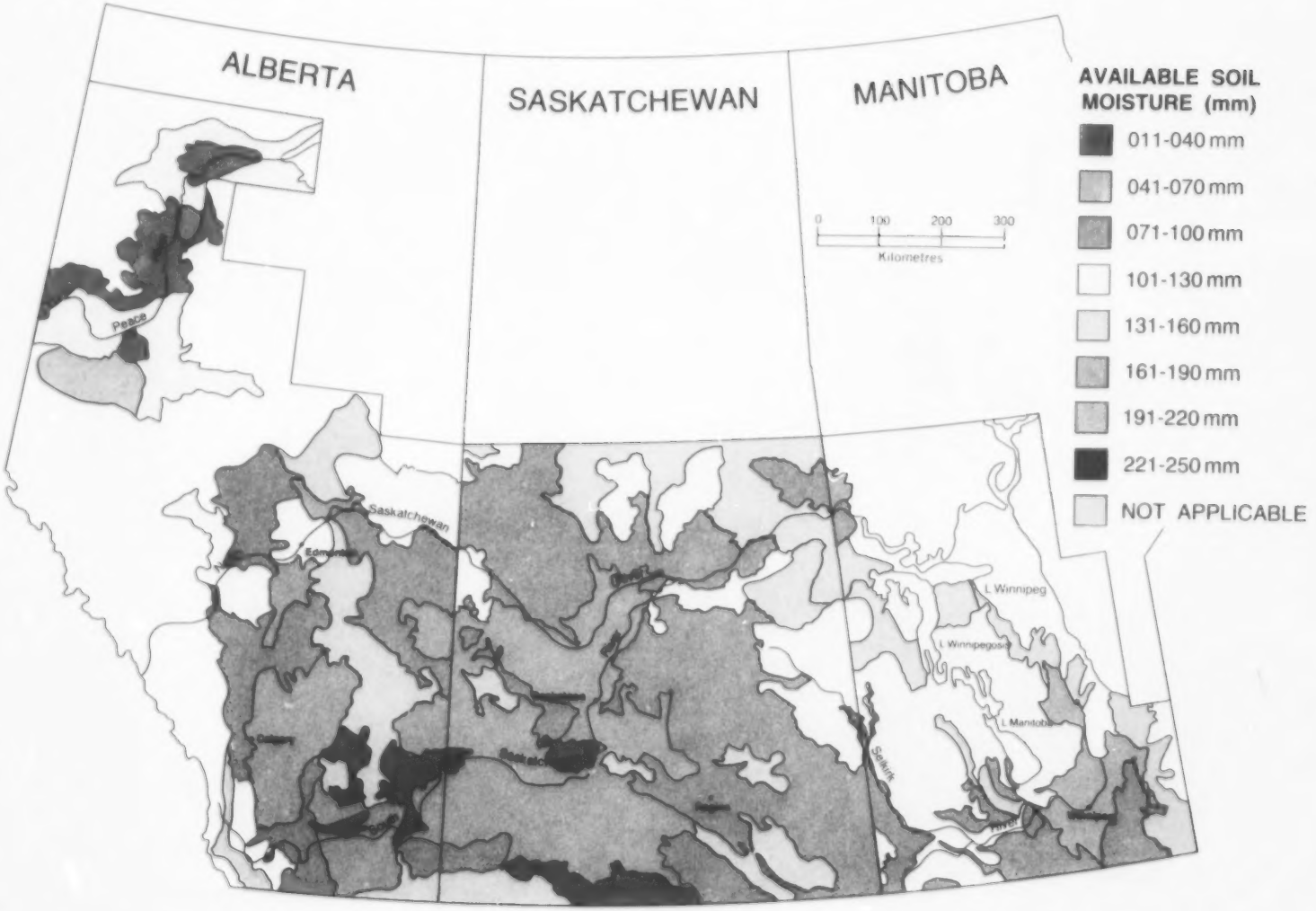


Figure 2. Available soil moisture (mm) at seeding in the wheat year for wheat/fallow rotation at 50% probability.

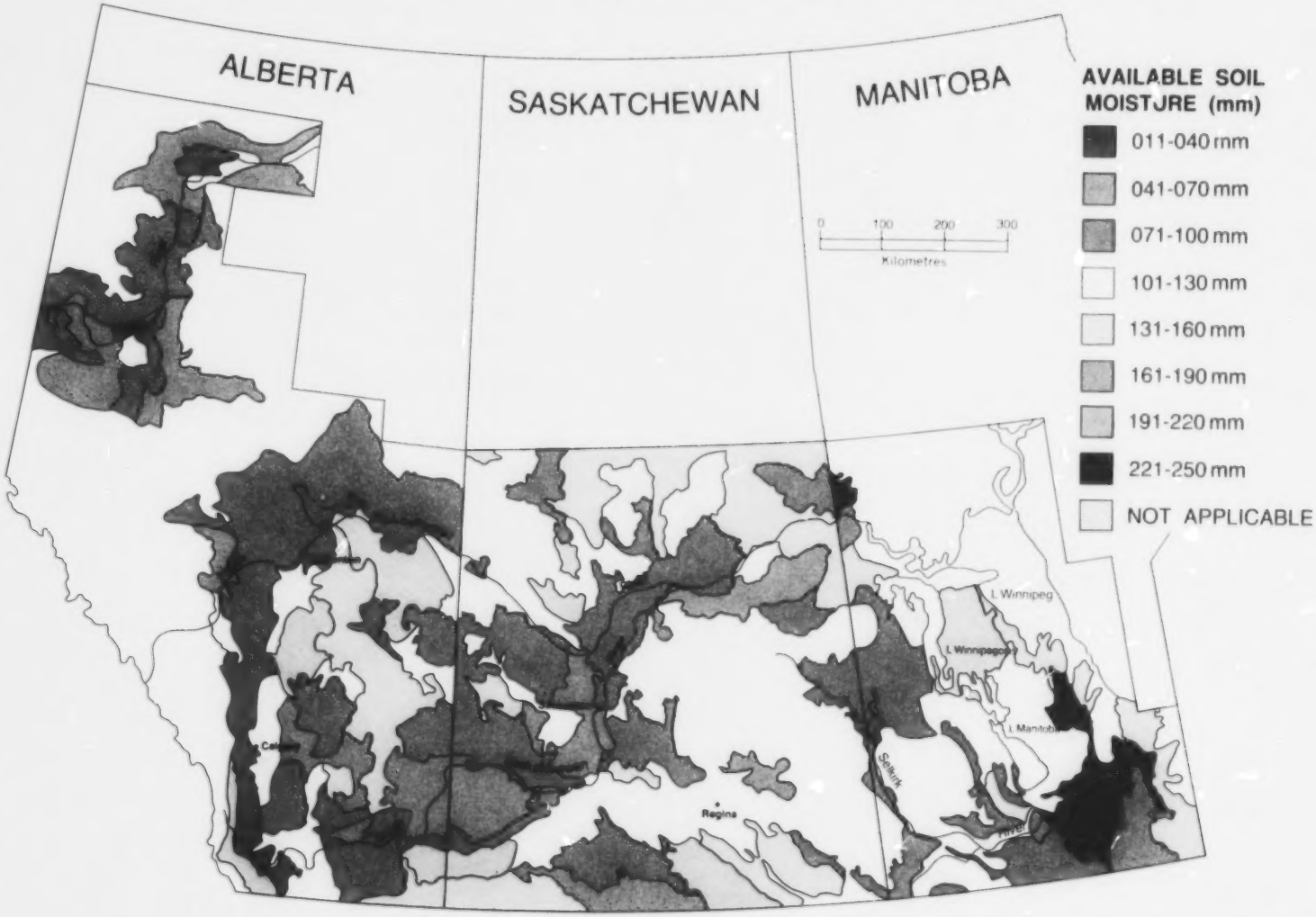


Figure 3. Predominant soil available water holding capacity (AWC) used in Figures 1 and 2 for each ARA.

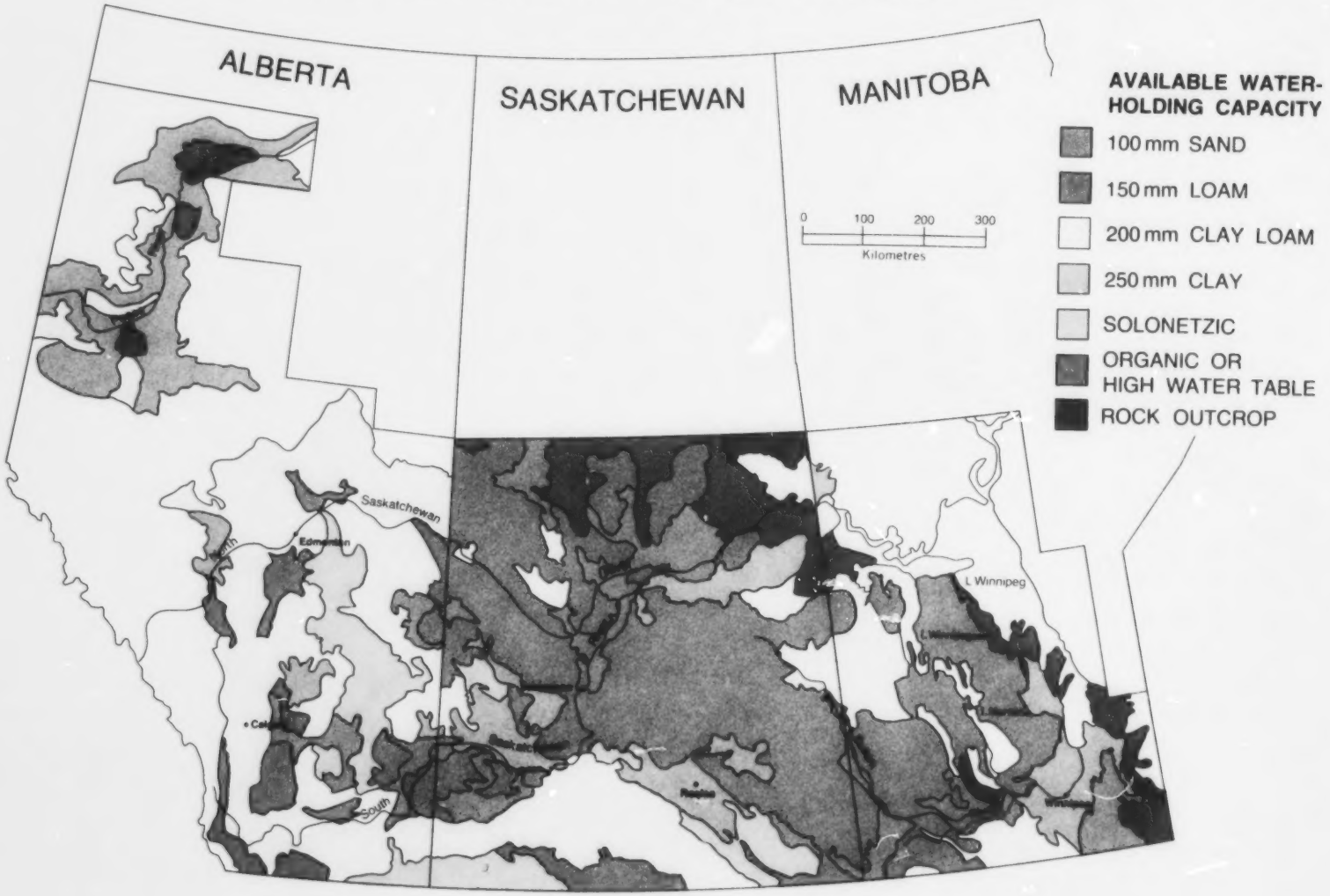
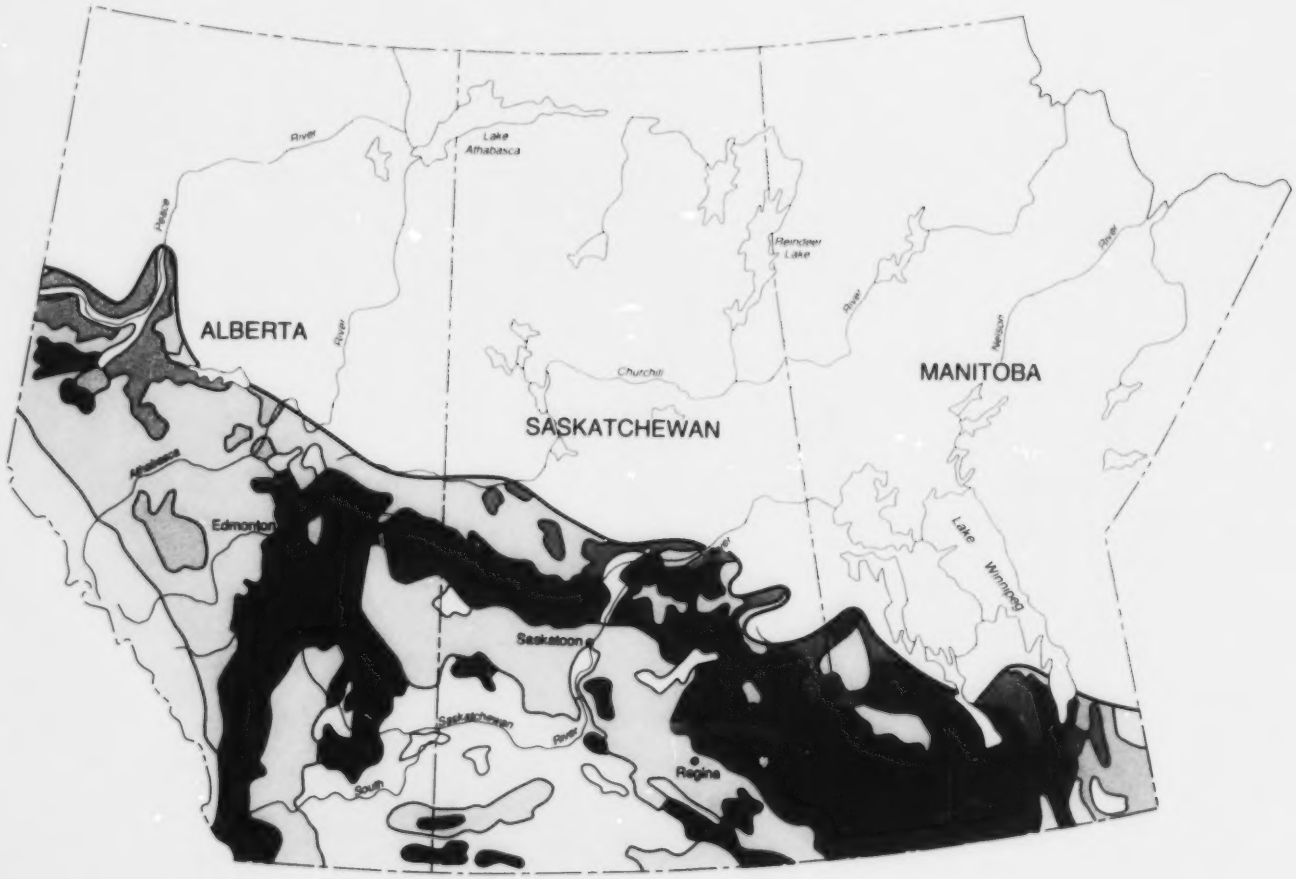


Figure 4. Location of major soil groups in the prairie region



SOIL GREAT GROUP
OR
SUBGROUP

A: DOMINANTLY CHERNOZEMIC
- BROWN CHERNOZEMIC
- DARK BROWN CHERNOZEMIC
- BLACK CHERNOZEMIC
- DARK GRAY CHERNOZEMIC

B: DOMINANTLY SOLONETZIC
- BROWN SOLONETZ*
- BLACK SOLONETZ*
- SOLOD

C: DOMINANTLY LUVISOLIC
- GRAY LUVISOL

F: DOMINANTLY REGOSOLIC
- ORTHIC REGOSOL*

G: DOMINANTLY GLEYSOLIC
- HUMIC GLEYSOL

H: DOMINANTLY ORGANIC
- FIBRISOL

- DOMINANTLY ROCKLAND

*Subgroup level of soil classification

Figure 5. Available soil moisture (mm) at seeding for 250 mm soil AWC, 10% probability, continuous wheat rotation.

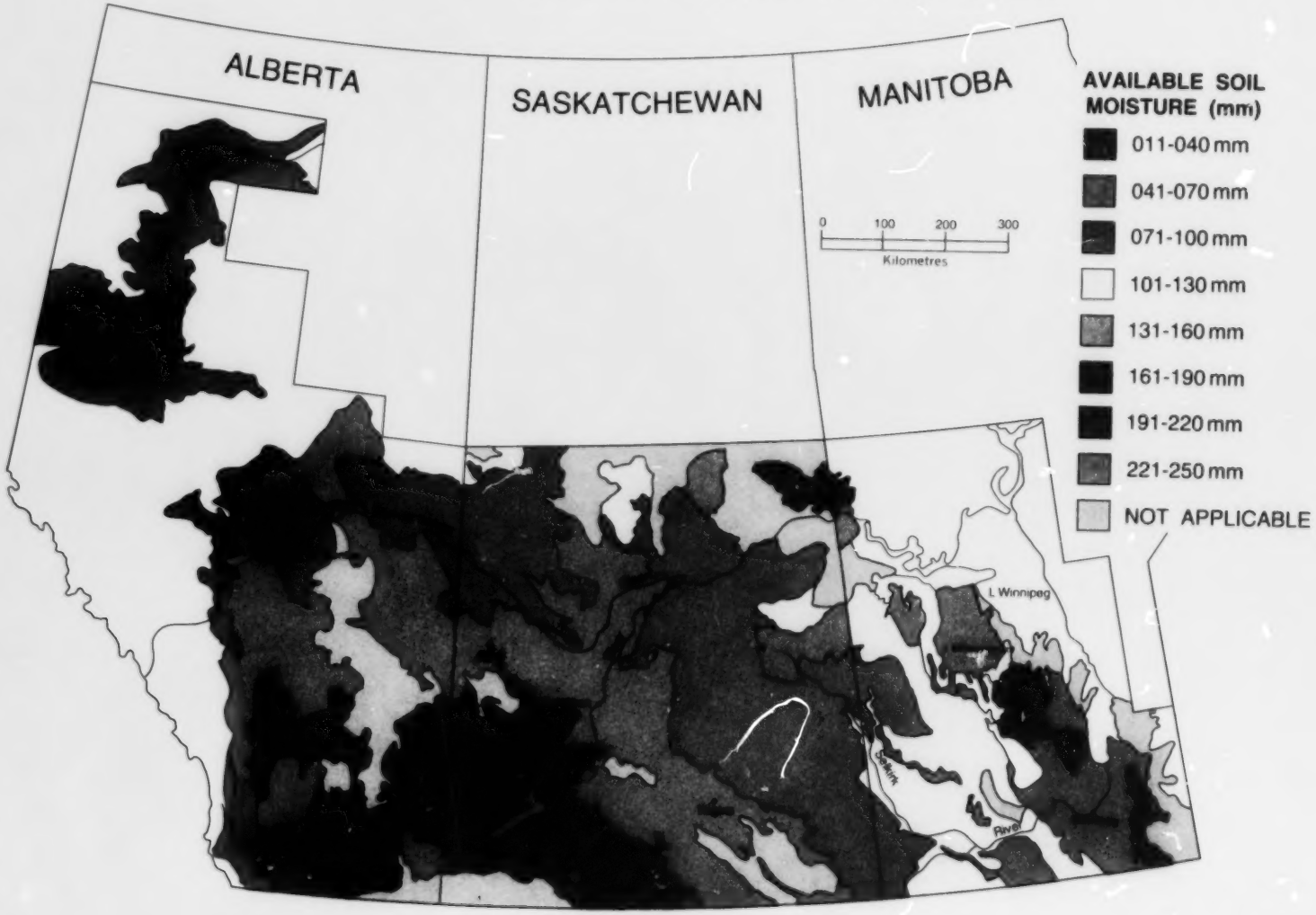


Figure 6. Available soil moisture (mm) at seeding for 250 mm soil AWC, 10% probability, wheat/fallow rotation.